NOISE AND VIBRATION IN ARMY AVIATION
01 OCT 2010

TERMINAL LEARNING OBJECTIVE

Action:	Protect yourself from the effects of noise and vibrations in Army aviation
Conditions:	While serving as an aircrew member
Standards:	In accordance with (IAW) TC 3-04.93, AR 40-501, DA Pam 40-501 and Fundamentals of Aerospace Medicine, 3rd ed

ENABLING LEARNING OBJECTIVE A

Action:	Identify terminology associated with sound
Conditions:	Given a list of terms and definitions
Standards:	Correctly identify terms related to sound and the characteristics of sound

1. **Sound** is mechanical radiant energy that is transmitted by pressure waves in a material medium (such as air) and is the objective cause of hearing

    a. Sound is produced when an object or surface vibrates rapidly and generates a pressure wave or disturbance in the surrounding air

    b. Colliding molecules produce vibrations and pressure increases or a “compression”. Molecules rebounding away from each other produce a lower pressure or a “rarefaction”

    c. Sound can be transmitted through any elastic substance such as air, water, or bone

    d. The density of the substance determines the speed at which the sound and pressure waves will travel. The denser the substance, the faster and longer the sound will travel

2. **Hearing** is the perception of sound. Pressure waves must pass through three areas of the ear to allow the brain to perceive sound. To better understand why aviation personnel lose their hearing, it is important to understand the mechanism of hearing

    a. The **external ear** is the visible portion of the ear and the external auditory canal, which ends at the eardrum. Sound is transmitted by air in this portion of the ear

    b. The **middle ear** is the small, air-filled cavity that separates the external and inner ear. Three small bones or ossicles, which are the malleus, incus and stapes (hammer, anvil, and stirrup), link the eardrum to the inner ear and mechanically carry sound to the hearing receptors. The Eustachian tube connects the middle ear with the nasopharynx and permits drainage and ventilation of the middle ear. It also equalizes pressure between the outside ear and the middle ear

    c. The **inner ear** is the third component that lies deep within the temporal bone. It consists of two sections; the vestibular section which senses balance and the auditory portion, which is the **cochlea**. It is comprised of a fluid-filled chamber where the hair-like receptors for hearing are located. The movement of the ossicles causes hydraulic movement of the fluid. The hair cells detect this fluid movement and transmit electrical impulses to the brain where sound is interpreted. The hair cells are grouped into frequency specific bundles. Destroyed hair cells in the various bundles means loss of sound perception in that frequency range

d. Sound of any type generates movement of fluid that stimulates the hair cells to convert mechanical impulses into electrical impulses. Loud sounds may fatigue these cells to the point where it may take several hours of relative quiet before they can revert to their normal state

EXAMPLE: Hair cells can be compared to blades of grass. Walking on the grass causes it to bend, but then it springs back over time. However, if you walk on the grass continuously, the grass will die and no longer spring to life. Hair cells damaged from prolonged exposure to noise will not spring back

ENABLING LEARNING OBJECTIVE B

Action:	Identify the effects of noise on the body
Conditions:	Given a list
Standards:	Correctly identify the characteristics of noise and the acceptable levels of noise

1. **Noise** is defined as sound that is loud, unpleasant or unwanted; however, sound does not have to be loud to be considered noise. It is contingent on how the listener perceives it. In aviation, noise can cause annoyance, speech interference, fatigue and hearing loss

    a. **Annoying noise** can affect pilots while they are performing their duties because it interferes with concentration

    b. **Fatigue** can be caused by a number of physiological responses that have been attributed to noise. Reported responses include effects on blood flow to the skin, respiration, skeletal muscle tension, and constipation

    c. **Speech interference** occurs when noise masks and obscures words

    d. **Hearing loss** can occur due to exposure to noise that is above safe limits and damage may be either temporary or permanent. The bottom line is that over exposure to noise destroys your hearing

2. **Characteristics of noise** (measurable)

    a. **Frequency** is the physical characteristic that gives sound its subjective quality of pitch. Frequency of periodic motion is the number of times per second the air (pressure waves) oscillates. The number of oscillations, or cycles per second, is measured in **Hertz (Hz)**

        1) **Human hearing range**: The human ear is very sensitive and can detect frequencies from 20 to 20,000 Hz
        2) **Human speech range**: Speech involves frequencies from 200 to 6,800 Hz. This is the range to which the ear is most sensitive
        3) **Speech intelligibility**: You must be able to hear in the range of 300 to 3000 Hz to understand speech communication

    b. **Intensity** is the physiological correlation of sound intensity or pressure to loudness. For auditory measurement it is convenient to convert the physical measurement of intensity to a logarithmic scale known as the **decibel (dB)** scale

1) 0 dB. Close to the human hearing threshold or the smallest sound heard by the average normal human ear. It is NOT the absence of sound
2) 65 dB. Average level of conversational speech with moderate level of vocal effort
3) 85 dB. Level of steady noise that is considered hazardous regardless of the duration, hearing conversation measures must be taken when exposed to noise level at or above 85 dB
4) 120 dB. This is known as the "discomfort threshold". This level of noise is uncomfortable to the human ear
5) 140 dB. Level of noise that will produce pain in the average human ear, known as the "pain threshold"
6) 160 dB. Physical damage may result at this level of noise. The eardrum may rupture and the noise (pressure) may be forceful enough to disrupt the ossicles in the middle ear

NOTE: Since the decibel is a logarithmic ratio, a 20 dB increase equals a pressure increase of 10 times. The entire range of human hearing from 0 dB to 140 dB shows a 10 million fold increase in sound pressure

c. **Duration** is characterized as how long you are exposed to noise

1) **Steady noise** is sound without intermittence or significant variability in overall intensity for prolonged periods of time. This is the most common type of noise experienced in aviation and it originates primarily from engines, drive shafts, transmissions, rotors and propellers
2) **Impulse noise** is a type of sound characterized by explosive noise that builds up rapidly to a high intensity peak and falls off rapidly. This entire cycle is usually measured in milliseconds. It is defined as less than 1 second in duration

d. **Army noise exposure criteria**: The Surgeon General has established **85 decibels** as the maximum permissible sound level of continuous, unprotected exposure to steady-state noise for 8 hours

Exposure Duration per day (hours)	**Maximum Exposure level (dB)**
8	85
4	90
2	95
1	100
1/2	105
For every 5 decibel noise increase exposure, time is cut in half	

ENABLING LEARNING OBJECTIVE C

Action:	Identify the three types of hearing loss
Conditions:	Given a list
Standards:	Correctly identify the type of hearing loss with the cause

NOTE: Hearing loss depends on several factors such as age, individual's health, and the environment (lifestyle)

1. **Conductive hearing loss** occurs when there is a defect or impediment in the external or middle ear. This may be caused by wax, fluid, or calcification, which impedes the mechanical transmission of sound to the inner ear. In most cases it can be treated medically

2. **Sensorineural hearing loss** occurs when the cochlea is damaged. It is most frequently produced by noise, but can also be caused by heredity, disease, and aging. This hearing loss is permanent and usually occurs in the higher frequencies first. Substantial loss may occur before the speech frequencies are affected; there is no medical treatment for this type of loss; hearing aids may be beneficial

NOTE: **Acoustic trauma:** This type of damage to the ear is sudden and may cause temporary or permanent hearing loss. Acoustic trauma is caused by high intensity impulse noise. It can be single or repetitive in nature with the duration generally measured in milliseconds and usually in excess of 140 dB. Impulse noise (blast, gunfire, etc.) is usually predictable; therefore, acoustic trauma is usually preventable

3. **Presbycusis** occurs with aging

4. **Mixed hearing loss** is the combination of conductive loss and sensorineural loss. An air crewmember with high frequency hearing loss and a middle ear infection will have a conductive component that is treatable and sensorineural loss that is not

5. **Noise induced hearing loss (NIHL)**

    a. Temporary Threshold Shift (TTS) results from a single exposure to a high level noise. Threshold shifts may last for a few minutes or for a few hours, the duration of the shift depends primarily upon the duration, intensity, and frequency of the noise exposure. Recovery, when noise is removed, is usually complete

    b. Permanent Threshold Shifts (PTS) is the shift that occurs when exposed to continued noise for 15 hours and could eventually result in permanent loss. Recovery does not occur even though the noise exposure is terminated. Temporary threshold shifts may eventually become permanent. This process cannot be predicted

NOTE: Noise induced hearing loss is insidious because it is usually undetectable, painless and very gradual. Prolonged exposure to noise of moderate intensity may cause temporary and eventual permanent hearing loss. Noise intensity is usually below 140dB, but above 85 dB. Physical pain is usually NOT evident and there are often no symptoms whatsoever of any hearing loss. Initially, the higher frequencies of hearing are lost. When this becomes severe enough to interfere with speech communications, the individual will lose the ability to understand the sounds of consonants in words. Consonants consist of sounds in a higher frequency range than vowels. In the earlier stages communications becomes difficult in the presence of background noise

6. **Initial audiogram** is considered a “reference audiogram”. All subsequent audiograms will be measured against the initial reading

    a. Audiograms are considered normal as long as hearing thresholds are 20 dB or less for all frequencies tested. The acoustic notch begins with a drop in hearing in the 3000-4000 Hz range, with recovery at 6000 Hz

    b. Only physicians and audiologists can diagnose noise induced hearing loss

    c. Audiograms can detect inaccurate readings and will re-test the subject until normal patterns of audiometry are achieved

ENABLING LEARNING OBJECTIVE D

Action:	Identify the noise characteristics of military aircraft
Conditions:	Given a list
Standards:	Select the appropriate noise threat level of military aircraft, and the effect of that level IAW TC 3-04.93

1. **General findings in Army aircraft** (fixed & rotary wing)

    a. Overall noise levels are equal to or exceed 100 dB. This exceeds the average 85 dB damage risk-criteria

    b. The frequency that generates the most intense level is 300 Hz. Low frequency noise will produce a high frequency hearing loss. Providing adequate hearing protection for lower frequencies is very difficult due to the way lower frequencies are transmitted (vibrations)

    c. Prolonged exposures to these levels without hearing protection will lead to definite permanent noise induced hearing loss

2. **Noise in Army fixed wing aircraft** originates from power plants, propellers, and transmissions. Their noise levels will depend on the following criteria:

    a. Location of the engines and their proximity to the cockpit

    b. How much insulation they have (acoustic and vibration)

Aircraft	**dB**
C-12 / RC-12	*106
UC-35	**96
*Exterior noise level	**Cabin noise level

3. **Noise in Army rotary wing aircraft** originates from power plants, rotor systems, and transmissions that produce significant pure tone narrow bandwidth noise

    a. **Observation helicopters** are small in size but can generate an extreme amount of noise with levels exceeding 100 dB

    b. **Attack helicopters** such as the AH-64 Apache are closed cockpit helicopters; the rear seat occupant is exposed to engine noise at close proximity. Weapon systems can add more noise during mission profile

c. **Utility and cargo helicopters** noise levels fluctuate with cargo doors and ramps open. Troops that are being airlifted should wear hearing protection. Air crewmembers must ensure that passengers wear hearing protection while inside the troop/cargo compartment

Aircraft	dB
OH-58C	103
OH-58D	100
CH-47D	112
UH-60A	108
AH-64	104
*TH-67	102
*Based on noise level for Bell 206	

4. **Noise in Air Force cargo aircraft**. Due to our worldwide mission, air crewmembers may have to rely on cargo fixed wing aircraft to transport their aircraft to distant locations around the world

   a. Noise levels on cargo aircraft can exceed 85 decibels during air load operations on the ground

   b. As passengers, crewmembers could be exposed to noise levels well above the damage risk criteria

Aircraft	Maximum	Pilot-Cruise
C-5A	107 dB	85 dB
C-141	94 dB	84 dB
C-130	95 dB	84 dB
C-17	91 dB	90 dB

   c. During air load operations, ensure that you and aircrew wear hearing protection to minimize the potential for hearing loss

ENABLING LEARNING OBJECTIVE E

Action:	Identify methods to protect aircrew members from noise threats
Conditions:	Given a list
Standards:	Select the appropriate protective measures and when they are required to be employed

NOTE: A number of methods of protecting human hearing and/or controlling noise are available. Some methods are not economically feasible; others are not suitable for operational requirements. The following major methods of controlling noise must be considered

1. **Design or plan to eliminate the noise**. This is the ideal way of controlling noise

EXAMPLE: Design a new type aircraft with decreased noise levels

2. **Isolate the noise source**. Increasing the distance between the noise source and the exposed person can accomplish this

3. **Enclose the noise source**. This can be accomplished by using sound and energy absorbent material (baffling)

4. **Personal protective devices**. These are the most practical and economical methods available for noise protection. A number of devices are available to attenuate (reduce) the noise at an individual's ears

    a. **Personal protective measures** have certain distinct characteristics

        1) **Attenuation** is the amount of noise protection provided by a specific protective device. The attenuation of any given noise protective device is the number of dB it reduces from the total energy reaching the eardrum
        2) **Speech intelligibility** and other acoustic signals are better understood in noisy environments when noise protective devices are utilized. This is due to an increase in the signal to noise ratio brought about by a reduction in the masking effect of the noise
        3) **Maximum attenuation** for any device is approximately 50 dB. Above this point sound is transmitted to the inner ear by bone conduction (vibration)

    b. **Types** of personal protective measures

        1) **Ear plugs**. Foam, single flange, and triple flange; these devices are inserted into the external ear canal. They are inexpensive, easy to carry, and effective when fitted properly. They provide attenuation from 18-45 dB across the frequency band. They should be worn anytime you are exposed to noise levels in excess of 85 dB. They are very effective when worn in conjunction with the HGU-56, and IHADSS flight helmets

CAUTION: Ensure that your hands and earplugs are clean prior to insertion into the ear canal to eliminate ear infection

        2) **Ear muffs**. These devices are worn covering the ear. They provide 10-41 dB protection, across the frequency band, are comfortable, and because they can be readily seen, managerial control for wearing hearing protection are enhanced. Do not forget ground personnel or passengers. They are subject to hearing loss just as well as crewmembers
        3) **Headsets**. These devices are worn covering the ears, but also provide radio communication. Commonly worn in VIP type aircraft. Noise attenuation can be degraded due to rough handling, abuse, improper fits, and deteriorated ear seals. Headsets lack the crash attenuation protection provided by a helmet
        4) **Protective helmets:** For aviators and crewmembers, this is the best means of personal protection. They provide both noise and crash attenuation. The, HGU-56, and IHADSS provide greater protection in the higher frequencies. However, it is low frequency noise in the aviation environment that is the cause for concern

NOTE: The helmet is an excellent hearing protection device. It will provide optimal protection only if certain guidelines are followed: It must fit properly. It must be worn correctly. The ear cup seals must be soft, unwrinkled, and tear free. When the seals harden, they must be replaced

If the, HGU-56, and IHADSS helmets are worn properly, the noise attenuation brings the noise exposure within the confines of the damage risk criteria for every aircraft **except the UH-60, and CH-47**

NOTE: The polymeric foam (EAR) hand formed earplug in combination with the, HGU-56, and IHADSS helmets will provide additional protection from **ALL** aircraft noise in the US Army inventory. You may find that your ability to hear communications in the cockpit is diminished while using earplugs for the first time. This is due to the fact that your subconscious is adjusting to the lower sound intensity. You may feel that you have to concentrate and listen more closely to transmissions. Once you get used to listening with the earplugs in place, you will find it easier to hear

5) **Communication Ear Plugs (CEPs):** is a device used to improve hearing protection and speech communication. It includes a miniature transducer that reproduces speech signals from the internal communication system (ICS). The foam tip acts as a hearing protector, similar to the yellow foam earplugs pilots wear for "double hearing protection". A miniature wire from the CEP connects to the communications system through the mating connector mounted on the rear of the helmet. CEPs have been issued an airworthiness release (AWR) for all U.S. Army Aircraft using the HGU-56P and IHADSS helmets. One of the advantages of CEPs is that if there is a malfunction of the device, the aircraft communications can still be used

ENABLING LEARNING OBJECTIVE F

Action:	Identify sources of non-occupational noise exposure
Conditions:	Given a list
Standards:	Select the noise threat level associated with non-occupational noise

NOTE: Noise does not end at the flight line; thus our ears often never get the chance to recuperate from the noise exposure associated with flying. Aviators must be aware of the sources of potentially damaging noise exposure and take appropriate action to minimize these exposures

1. **General aviation**. Many aircrews have civilian private or commercial pilot certificates or instructor pilot ratings. They may fly for pleasure or additional income. This is an extremely critical source of exposure, since most private aircraft are flown without headsets, relying on speakers for hearing voice communications. Most single-engine light aircraft have noise levels in excess of 85 dB below 1000 Hz, which requires noise protection. Unprotected, air crewmembers could suffer noise induced hearing loss

2. **Weapons firing**. This applies to several categories of weapons firing. Unprotected, these impulse noises can result in sustained acoustic trauma. Some high velocity small arms weapons have peak intensities in excess of 168 dB. All small arms in the Army produce impulse noise levels above 140 dB. Noise protection should be used whenever air crewmembers are engaged in weapons firing. Some sources of indirect or non-occupational exposure are:

    a. Hunting, skeet or target shooting

    b. Annual weapons qualification

3. **Moonlighting**. A variety of off-duty jobs may expose the air or ground crewmen to additional potentially harmful noise exposures

    a. Bartending (95-110 dB) in a club where loud music is played

    b. Members of a “rock” band (110-150 dB)

4. **Contemporary music**. Frequently aircrews will innocently expose themselves to extremely loud and sustained levels of noise via music. Surveys in Officer and NCO clubs have revealed exposures and intensity levels that exceed 130 dB. This exposure has also shown to produce permanent hearing loss

    a. Personal portable radios aim high noise levels directly into the ear canal

    b. Portable stereo systems "boom boxes"

5. **Hobbies and recreation**. Often hobbies and recreation result in innocent and thoughtless exposure

6. **Household chores**. Even the simplest household equipment can expose you with unnecessary noise

    a. Lawnmowers (95-100 dB)

    b. Vacuum cleaners (90-100 dB)

    c. Blender (93 dB)

    d. Hair dryer (80 dB)

ENABLING LEARNING OBJECTIVE G

Action:	Identify vibration terminology
Conditions:	Given a list
Standards:	Correctly identify terms associated with vibration and the characteristics of vibration

1. **Vibration** is the motion of an object relative to a reference position (usually the object at rest) involving a series of oscillations resulting in the displacement and acceleration of the object

2. **Frequency** is the number of oscillations of any object in a given time, measured in cycles per second (cps). The international standard unit of frequency is the **Hertz (Hz)** (1 cps = 1 Hz)

3. **Amplitude** is the maximum displacement of an object from its position at rest

4. **Duration** is the amount of time exposed to vibration

5. **Natural body resonance** is the mechanical amplification of vibration by the body occurring at specific frequencies

6. **Damping** is the loss of mechanical energy in a vibrating system. This causes the vibration to slow down

    a. When the body is subjected to certain frequencies, the tissue and organs will begin to resonate (increase in amplitude)

    b. The connective tissue (muscle, tendons and ligaments) that binds the major organs together reacts to vibrations like a shock absorber

c. The reason why humans do not receive life-threatening injuries every time they go flying is due to the minor amplitudes of the vibration in the aircraft and the ability of the body to provide some damping against those vibrations

ENABLING LEARNING OBJECTIVE H

Action:	Identify sources vibration
Conditions:	Given a list
Standards:	Correctly identify sources of vibration and the threat associated with that source

NOTE: Vibrations are produced within all aircraft and in the environment in which the aircraft operates

1. Vibrations within the aircraft originate primarily from the **engines, the main rotor, and the tail rotor system**

2. **Increased airspeed, internal and external loading** of the aircraft can also cause increased vibration

3. **Environmental factors** (weather) such as turbulence may also intensify vibrations

4. Helicopter vibrations occur with similar intensities in all three planes of motion, (X, Y, and Z axis)

5. The amplitude of the vibration differs in each mode of flight. **The highest level of vibration occurs during the transition from flight to a hover and hover to fligh**t

ENABLING LEARNING OBJECTIVE I

Action:	Identify the effects of vibration on human performance during flight
Conditions:	Given a list
Standards:	Correctly identify the effect on the human body due to vibration

1. Vibration affects the aircrew member's ability to perform simple tasks during flight

2. **Manual coordination and control "touch"** is degraded at 4-8 Hz. Pilot induced oscillations occur when the aircrew member over controls during turbulence and/or transition from a hover to flight

3. **Vision** could be affected due to vibration in the aircraft; visual instruments may be difficult to read. Helmet mount or night vision devices may vibrate at 4-12 Hz

4. **Speech** can be distorted during oscillations of 4-12 Hz. Above 12 Hz, speech becomes increasingly difficult to interpret

5. Short term effects

NOTE: Vibration can cause short-term effects because of the body's mechanical properties. The human body acts like a series of objects connected by springs; the connective tissues that bind the major organs together react to vibration in the same way as springs. When the body is subjected to certain frequencies, the tissue and organs will begin to **resonate** (increase in amplitude). When objects reach their **resonant frequencies**, they create a momentum, which increases in intensity with each oscillation. Without shock absorption, vibration will result in damage to the mass or object

CAUTION: Helicopters subject aircrew members to vibrations over a frequency range that coincides with the resonant frequencies of the body. Prolonged contact with vibration causes short-term effects to the body. The reason why humans do not receive life-threatening injuries every time they go flying is due to the minor amplitudes of the vibration in the aircraft and the ability of the body to provide some damping against those vibrations

a. **Fatigue**
   1)Vibration causes the muscle to contract (exercise)
   2)When the human body is in motion, pressure receptors located in tendons and muscles constantly measure angular position of the muscles so as to maintain posture and balance
   3)These receptors respond to vibration causing contraction or tightening of the muscle. For example, vibration placed on both calves of a standing subject resulted in the subject experiencing the sensation of leaning forward (constant exercise)

b. **Respiratory effects**
   1)Hyperventilation is caused when the diaphragm is vibrated at 4-8 Hz
   2)The result of vibrating frequencies in the diaphragm will cause "artificial respiration"

c. **Circulatory effects**
   1)The body interprets vibrations experienced during flying as exercise. Therefore, the muscular effort of bracing against vibration increases pulse rate and blood pressure
   2)Heart and lungs exert more force to compensate for increased work load

d. **Motion sickness**

   1)Frequency of less than 1 Hz (slow rolling of a ship) can produce nausea in susceptible people
   2)Neural Mismatch Theory postulates that there is long term memory storage of the "correct world," in terms of movement as a terrestrial being, which is matched against the actual conditions. When these perceptions do not match, then the brain perceives an imbalance and initiates a reflex response in the stomach

e. **Disorientation**

   1)Vibration affects the semicircular canals (balance/coordination)
   2)Otolith organs affected due to vibration (overstimulation)

f. **Pain**

1)Any pre-existing injury will be aggravated by vibration
2)Stress fractures
3)Back pain
4)Degenerative disc disease (joint pain)

6. Long term Effects

CAUTION: Long-term exposure to vibration over a period of time may cause injury to air crewmembers

a. **Raynaud's Disease** (White finger) occurs to the hands after prolonged exposure to vibration from power tools, jackhammers, or other such equipment that vibrates at high frequencies. Trauma occurs in the arterioles and nerve endings in the extremities and limits the blood flow to that portion of the extremity

b. **Backache/back pain** in aircrew member may result at an earlier age than normal

1)The lumbar spine, in particular, is subjected to higher pressures during aircraft operation because the weight of the torso on that part of the spine while sitting. When the body is standing, the legs support most of the body's weight
2)Bone, like other organs, requires blood to provide nutrients for life. When the spine is subjected to high levels of vibration, blood flow is reduced. The reduction in blood flow results in premature degeneration of bone structures within the spine. If you bend steel back and forth enough times, you can produce a weak section, which will eventually break. This same principle can be applied in understanding injuries to the spine

c. **Kidney and lung damage:** Currently under scientific study, the signs and symptoms of the effects of vibration on the functions of organs include blood in the urine (kidney), and damage to lung tissue after prolonged exposure to vibration (especially resonant frequencies)

ENABLING LEARNING OBJECTIVE J

Action:	Identify the method(s) used to reduce the vibration threat in Army aviation
Conditions:	Given a list
Standards:	Correctly identify the appropriate method(s) used to protect aircrew members from the effects of vibration

NOTE: Vibration in Aviation cannot be eliminated, but its effects on human performance and physiological functions can be lessened

1. **Maintain good posture** during flight; sitting straight in the seat will enhance blood flow throughout the body

2. **Restraint systems** provide protection against high magnitude vibration experienced in extreme turbulence

WARNING: Body supports such as lumbar inserts and seat cushions reduce discomfort and can dampen vibration; however, during a crash sequence they may increase the likelihood of injury due to their compression characteristics

3. **Maintain your equipment**. Proper aircraft maintenance such as rotor blade tracking and balancing can reduce unnecessary vibration exposure

4. **Isolate the aircrew members or passengers** from the aircraft surfaces. When loading patients on MEDEVAC aircraft, remember that patients placed on the floor will experience more vibration than patients placed on the litter support system (carousel)

5. **Limit your exposure time**. Make short flights with frequent breaks, rather than one long flight, if mission permits

6. **Let the aircraft do the work**. Do not grip the controls tightly. Vibration can be transmitted through control linkages during turbulence

7. **Maintain excellent physical condition**. Fat multiplies vibration, while muscle dampens vibration. Strong muscles act to reduce the magnitude of oscillations encountered in flight (damping). An overweight aircrew member is more susceptible to decrements in performance and the physiological effects to vibration

8. **Maintaining good physical condition** also lessens the effects of fatigue. Good physical condition permits you to continue to function during extended combat operations with minimum rest

9. **Maintain sufficient hydration**. Drink plenty of fluids, even if you don't feel thirsty, a minimum of two quarts of water over and above fluids taken with meals. Dehydration coupled with vibration can cause fatigue twice as fast, and it will take twice the time needed for recovery

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